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# Cerium Oxide for Glass Polishing

*by* ***L. K. Duncan,*** Senior Research Chemist, Vitro Chemical Company, Research and Development Department, Chattanooga, Tennessee

ELECTRON PHOTOMICROGRAPHS PREPARED BY MISS PAULINE HOLBERT

● THE USE OF CERIUM oxide-based glass polishing oxides in the United States dates from about 1943. This application began in the European glass industry around 1933, spreading to the Canadian optics trade in 1940-41. No single individual has been generally associated with the first use of ceria for glass polishing. Ceria was neither recognized as a superior glass polish nor available in commercial quantities prior to World War II. Military requirements for rapid, precision polishing of optical glass accelerated its development for this purpose and set the stage for the rapid increase in its use for commercial glass polishing during the post-war years.

The use of cerium oxide for polishing has increased in the past fourteen years to more than 750,000 lbs./yr. at the present time. Its major applications are for polishing of mirrors, plate glass, television tubes, lenses, and precision optical glass. The number and variety of polishing oxides being produced for the glass industry in this country is growing rapidly. There are in current use more than fifteen different products, based on oxides of cerium, zirconium, iron, silicon, tin, and chromium.

## Processing

The primary raw material for U. S. production of cerium-rare earth polishing oxides has to this time been the mineral monazite, essentially a rare earth-thorium phosphate. A secondary potential source of these oxides, but one from which they may be increasingly obtained in the future as the government's diminishing needs for crude thorium reduce the attractiveness of monazite processing, is the rare earth fluocarbonate mineral, bastnaesite. As an indication of the relative abundance of these materials, the estimated 1958 capacity for processing of monazite was 16,800,000 lbs.; bastnaesite, 4,800,000 lbs. of contained rare earth oxide.

Monazite can be satisfactorily processed with either sulfuric acid or caustic. The sulfuric acid process, the more familiar and widely used of the two, was presented in a recent issue of this journal[1]. For present consideration, therefore, attention will be centered on the caustic process, a method originally developed by the Rare Earth Group of Pechiney of France. Figure 1 is a simplified flow sheet for preparation of high-and low-cerium oxides from monazite by this process.

The intermediates from which high-cerium oxide and low-cerium oxide are derived are cerium hydrate and rare earth carbonate or hydrate, respectively.

Cerium hydrate is the term applied to the hydrous oxide, or hydroxide, of tetravalent (ceric) cerium. It is obtained by slow addition of chlorine and sodium hydroxide to oxidize trivalent (cerous) cerium in the crude rare earth chloride solution at a controlled acidity. From

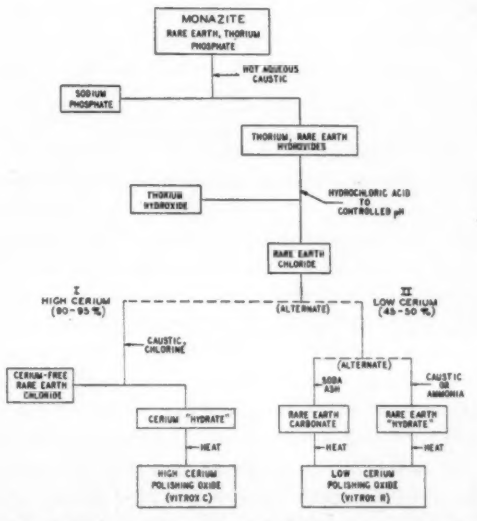



FIG. 1. Derivation of cerium-rare earth oxides via caustic processing on monazite.

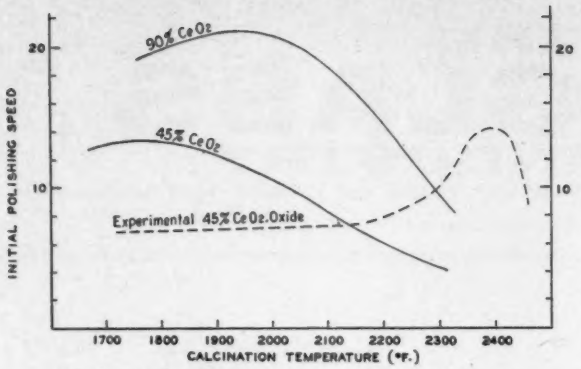



FIG. 2. Initial polishing speed vs. calcination temperature.

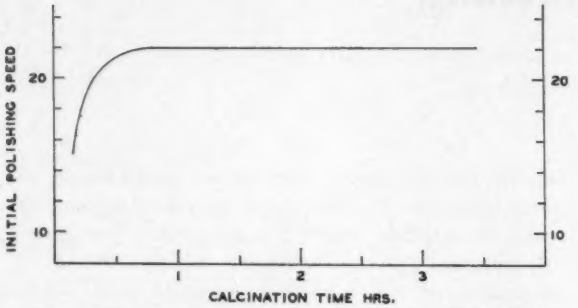



FIG. 3. Initial polishing speed vs. calcination time (90% CeO)

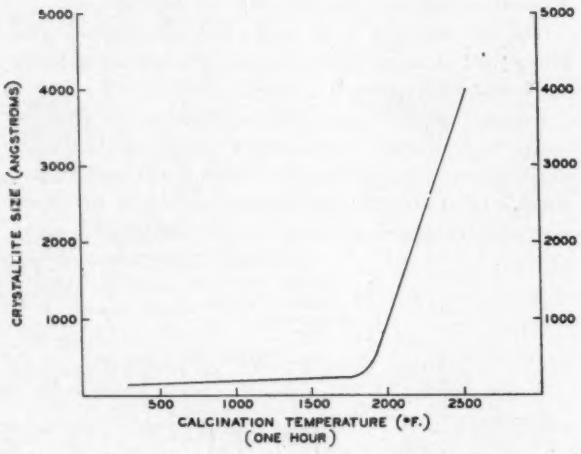



FIG. 4. Cerium oxide crystallite growth vs. calcination temperature.

a feed solution containing 45-50 per cent $CeO_2$/total oxides a cerium hydrate is obtained with 90-92 per cent $CeO_2$/total oxides. Precipitation of cerium hydrate in this fashion can only be done from a chloride solution, one characteristic feature of the caustic process, as distinguished from the sulfuric acid process. The chlorine oxidation method yields a microcrystalline cerium hydroxide well suited for calcination to a polishing oxide.

Rare earth carbonate, the usual intermediate in production of low-cerium oxide is obtained simply by controlled addition of sodium carbonate to the low-cerium (45 per cent $CeO_2$/total oxides) rare earth chloride

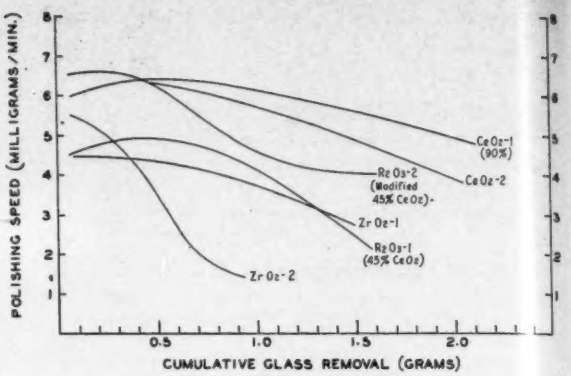



FIG. 5. Polishing oxide durability.

solution. The carbonate is outwardly a more coarsely crystalline material than cerium hydrate, but decomposes on calcination to a fine powdery oxide with particle size predominantly below 10-15 microns. Alternately, a rare earth "hydrate" of this same cerium content can be prepared by addition of dilute ammonium hydroxide or caustic to the rare earth chloride solution.

Modification of either the high-cerium or low-cerium oxide, to alter its polishing characteristics for certain specific applications, is sometimes effected by appropriate changes in the technique of precipitating the carbonate or hydrate, by minor additions to these materials prior to calcination, or by modifications in the physical treatment of the calcined oxide.

Calcination is generally recognized as one of the primary factors in the quality of any polishing oxide, be it ceria, zirconia or iron rouge. In a very general way, any given type of oxide can be subdivided into soft, medium, and hard—or low-fired, normal, and high-fired—forms, depending solely on the degree to which it has been calcined. Characteristics of so-called "soft" oxides are low polishing speed and short useful life, but often superior surface quality of the polished item. Hard oxides, on the other hand, will polish faster and continue to do so for a longer time, but tend to scratch some forms of glass. Normal production oxides represent an optimum compromise of these extremes, satisfying most industrial requirements for rapid polishing, long useful life, and high surface quality.

The effect of calcination temperatures on the initial polishing speed of high-cerium and low-cerium oxides is illustrated in Fig. 2. While oversimplifying the problem by discounting the other factors pertinent to the over-all quality of an oxide, this does serve to indicate the critical nature of calcination temperature.

The decrease in initial polishing speed of oxide fired at higher temperatures arises both from densification of the oxide, reducing its effective surface area, and from chemical inactivation of the oxide for polishing purposes. The higher position of the curve for 90 per cent $CeO_2$ oxide reflects its higher cerium-content, ceria being the active ingredient in any ceria-rare earth mixture. The dotted curve for an experimental low-cerium oxide illus-

trates the wide variation in nature of the temperature dependence of different oxides. This particular oxide does not attain its peak polishing performance until calcined at approximately 2300°F., far above the optimum temperature for either of the other two oxides. It is generally more desirable for an oxide to have its maximum performance realized by calcination at the lowest possible temperature, thus minimizing the possible harmful effects of some trace impurities which might seriously inactivate the oxide or even sinter to form hard, scratching particles, at 2200°-2300°F.

Calcining time is also a critical factor, though less so than temperature. The curve in Fig. 3 shows the sharp decrease in initial polishing speed of a high-cerium oxide when calcined at optimum temperature for insufficient time.

Growth of the cerium oxide crystallite to a size suitable for glass polishing is one of the most important basic changes occurring during heating. The striking temperature dependence of this growth rate is shown in Fig. 4, where crystallite size, as determined by X-ray diffraction, is plotted against temperature of firing[2].

The possibility of contaminating polishing oxides with harmful impurities, however slight, always exists in a commercial chemical plant. These impurities can comprise metallic particles from the processing equipment or gritty oversized oxide agglomerates from calcination, either being capable of scratching soft glasses. The primary source of microscopic scratches in polished glass surfaces are these hard foreign particles, even when present in concentrations less than 0.001 per cent.

Methods for eliminating these contamination hazards include dry- and wet-milling, aqueous classification or elutriation, and air classification. Milling operations are inherently laborious and slow, and they do not always eliminate scratching even when the offending impurities are ground to extremely small size. Both aqueous and air classification rely on differences in density and particle size to effect separation of product oxide from contaminants. Aqueous elutriation systems are based on controlled flow of oxide slurry through vertical towers or cyclone-type centrifugal separators. Classification by flow of high velocity air in controlled vortex classifiers is a rapidly developing and promising technique for obtaining oxides with specific particle sizes. The versatility and operating economy of such classifiers make them attractive for the polishing oxide industry, although their initial expense is high.

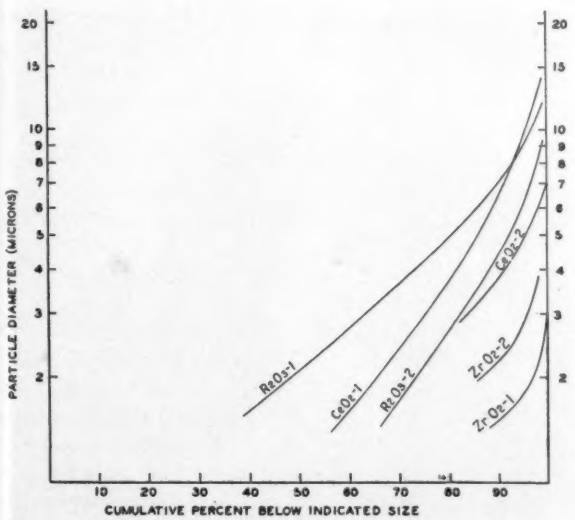


FIG. 6. Particle size distribution of polishing oxides.

## Evaluation

The basic premise that reliable analytical procedures create the foundation for any chemical product is particularly true for glass polishing oxides. All the precautions with which a manufacturing process is developed, and a polishing oxide is produced, are meaningless in the absence of reliable methods for determining that the oxide will do the job for which it is intended. For this reason the continued development of accurate analytical procedures for polishing oxide evaluations is of primary concern in the laboratories of most oxide manufacturers.

Routine evaluations of industrial oxides are almost entirely based on ability of these oxides to remove glass during a polishing operation. Direct correlation between glass removal and polishing, though not in every case completely true, is generally assumed for control purposes, and precise measurement of either changing weight or thickness of a test piece is the customary basis for oxide testing. A primary fault of such methods lies in the fact that equal degrees of polishing can sometimes be produced with different oxides, one of which may require removal of more glass than the other in so doing.

Testing methods based on evaluating a glass surface during the course of polishing and hence determining the minimum time required for perfect polishing are hampered by the difficulty of objectively measuring, preferably by instrumental methods, a polished surface. Instrumental methods based on light transmission, reflection, or scattering have generally not been sufficiently sensitive to measure the last traces of imperfections present in the glass surface during the final phases of polishing. Techniques such as electron photomicroscopy, suitable for experimental purposes, are too tedious and involved for routine testing.

Laboratory control methods are primarily concerned with measurement of the initial polishing speed, durability or useful life span, scratching tendency, and particle size distribution. Special applications sometimes dictate more involved testing.

The initial polishing speed of an oxide, while a fairly reliable guide for preliminary evaluation and screening and for quality control with one specific type of material, is often a deceptive measure of the over-all performance characteristics of a polishing oxide. The durability, or useful life, of an oxide in prolonged polishing gives a better picture of its practical performance. Figure 5

FIG. 7. Electron microscope photographs of glass surface after 1 minute of polishing with cerium oxide. (6000X Magnification)

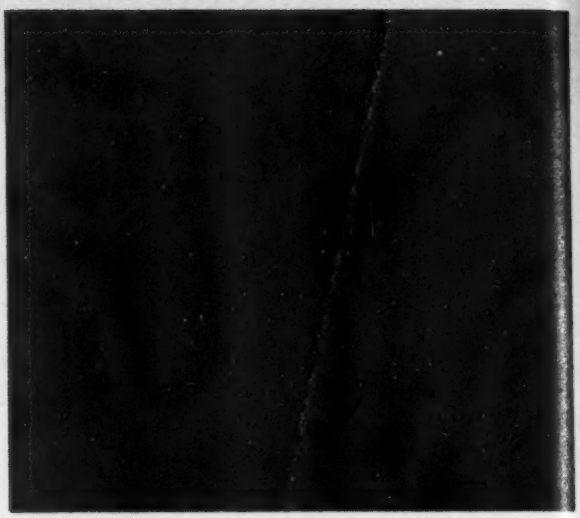


FIG. 8. Electron microscope photographs of glass surface after 10 minutes of polishing with cerium oxide. (6000X Magnification)

presents durability curves obtained with several different polishing oxides under identical test conditions.

It will be noted that the initial polishing speed of an oxide is less significant, for most applications, than its ability to maintain a good polishing rate for long periods of time. The shape of these durability curves generally characterize their respective oxides and relate largely to the particle size distribution, firmness of large particle agglomerates, and strength of the ultimate oxide crystal. An oxide containing relatively large amounts of agglomerates in the 8-20 micron range will show a slight increase in polishing speed over the first 1-2 hours as the larger agglomerates are degraded to their true crystallite size and become more active in the polishing process. After reduction of gross agglomerates to crystallites is essentially completed, the oxide shows a gradual decrease in polishing power due to complete attrition of the crystallites and saturation with the products of the polishing operation.

Oxides of predominantly fine particle size have no such agglomerate "reservoirs" of active polishing crystallites, and thus tend to drop rather rapidly in polishing speed. For example, high-cerium oxide which has been so classified as to remove all particles larger than seven microns shows the effect of this absence of agglomerates ($CeO_2$-2, Fig. 5). High initial polishing speed can thus often be achieved by classifying an oxide to an extremely fine particle size, but not without sacrificing to some

*Figures 9 through 12 are electron microscope photographs of polishing oxides.*

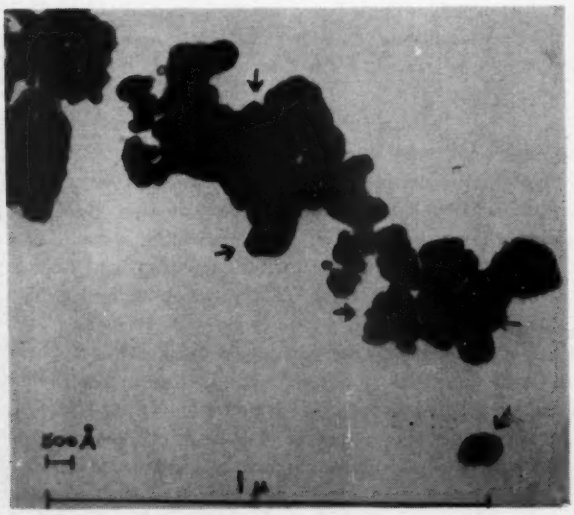



FIG. 9. Oxide 1. $CeO_2$

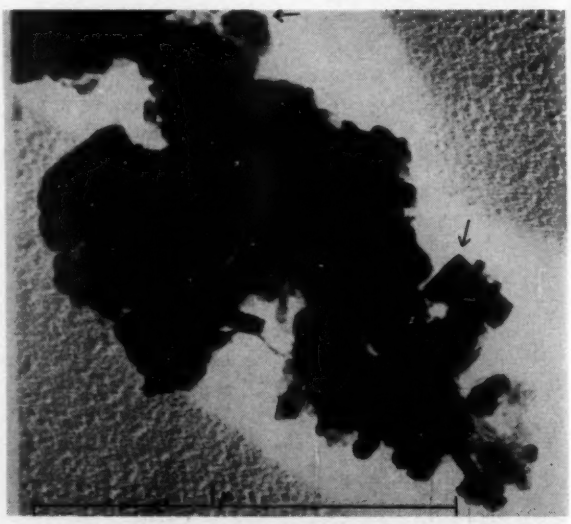


FIG. 10. Oxide 2. $CeO_2$

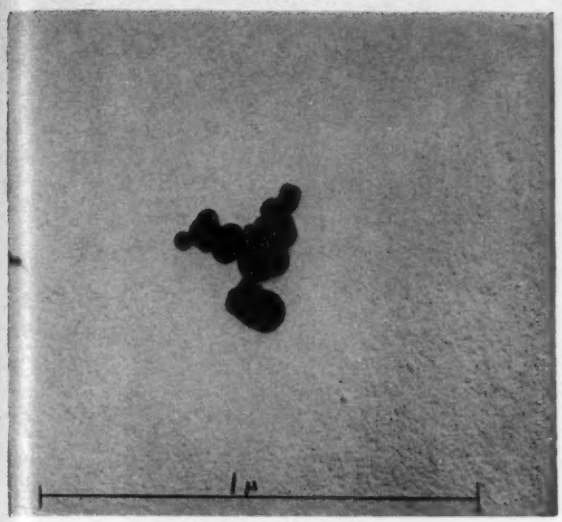



FIG. 11. Oxide 3. $ZrO_2$

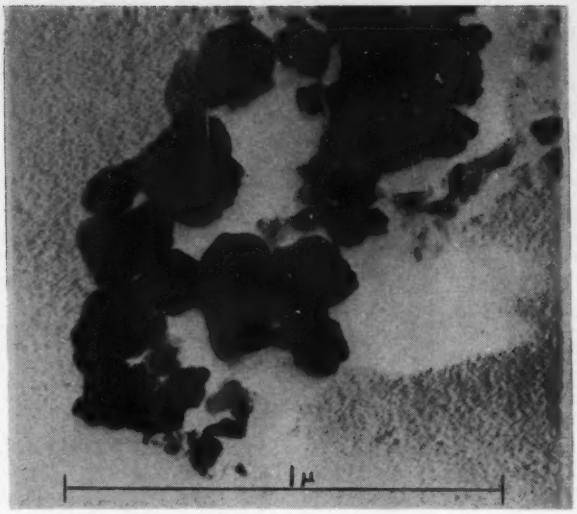



FIG. 12. Oxide 4. $ZrO_2$

extent its power to continue effective polishing for prolonged periods. Some representative particle size analyses of the oxides whose durabilities are shown above are presented in Fig. 6.

The useful upper limit of agglomerate size and firmness, of course, is the point at which scratching and abrasion, rather than polishing, occurs. Routine testing of polishing oxides for tendency to scratch various types of hard and soft glass is therefore a necessary part of oxide quality control.

While the initial polishing speed of a ceria-based oxide is generally proportional to its ceria-content, considerable variation in polishing speed of materials with a given percentage of cerium can result from changes in the method of precipitation or the parent compound from which the oxide is derived. For example, a pure ceria resulting from calcination of cerium hydrate may polish as much as 100 per cent faster than pure ceria obtained by calcination of cerium oxalate under the same conditions. Such apparent anomalies are generally attributed to inherent differences in the properties of the cerium oxide crystal obtained from the different starting compounds. In this respect the rare earths present in a low-cerium mixture, though not active polishing agents themselves, can affect its polishing ability by altering the crystal structure of the ceric oxide.

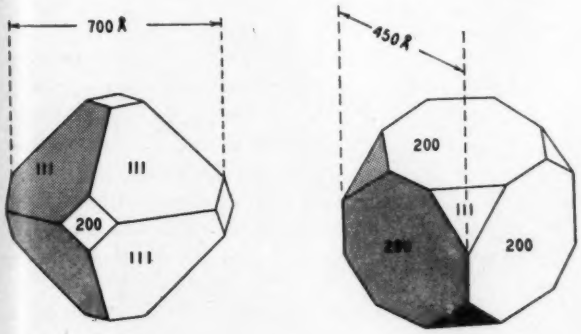



FIG. 13. Crystal habits of cubic cerium oxide as postulated from X-ray data.

## Theories of Glass Polishing

This author does not presume to offer any profound new insights into the phenomenon of glass polishing. It does appear pertinent, however, to consider in brief review some of the more recent studies in this field, conclusions of which have been more or less in accord with experience at Vitro Chemical Company.

Most of the prevalent theories of glass polishing seek to explain the process through:

1. purely physical, thermal softening and displacement of the glass surface.
2. chemical reactions involving all the components of a polishing system—pad, water, polishing oxide, glass.
3. a combination of these factors.

There is much evidence justifying the conclusion that glass polishing does involve both chemical and physical processes, the chemical aspect playing possibly the most significant role, certainly a more influential one than has been generally attributed to it until the past decade. Much progress toward a better understanding of polishing has been made since the early 1950's with the application of the electron microscope to the investigation of glass surfaces during polishing. The type of surface characteristics revealed by the electron microscope at 6000X magnification are shown in the micrographs representing a fined lens surface after 0 (see cover), 1 (Fig. 7), and 10 (Fig. 8) minutes of polishing with cerium oxide. Even this technique, however, has not revealed the basic explanation of the process—the precise physico-

(*Continued on page* 412)

FIG. 1. Officers of the Glass Division of the American Ceramic Society—1960. Left to right: Frank R. Bacon, Owens-Illinois Technical Center, past chairman; Clarence L. Babcock, Owens-Illinois Technical Center, chairman of the Symposium on Heat Transfer Phenomena in Glass; Guy E. Rindone, Pennsylvania State University, chairman; Fay V. Tooley, University of Illinois, secretary; August C. Siefert, Owens-Corning Fiberglas Corp., trustee, and J. R. Hensler, Bausch and Lomb Optical Co., vice-chairman, were absent when this picture was taken.

# 62nd A.C.S. Annual Meeting

## GLASS DIVISION PAPERS

***Fall Meeting, Glass Division:***
***Bedford Springs Hotel, Bedford, Pa., Oct. 12-14, 1960.***

***ACS Spring Meeting:***
***April 23-27, 1961, Royal York Hotel, Toronto, Ontario, Canada.***

● THE 62ND ANNUAL MEETING of the American Ceramic Society was held in Philadelphia, Penna., April 24-28. All technical papers of the Glass Division were presented at the Warwick Hotel. Approximately 2700 people were registered for the meeting, of whom 400 were women. There were more than 60 members from Canada, Mexico, and Great Britain, and from a number of countries on the Continent.

The Glass Division Program comprised over twenty papers devoted to various phases of glass technology, and nine papers featured a symposium on "Heat Transfer Phenomena in Glass." This most interesting symposium was arranged by Clarence L. Babcock, Owens-Illinois Technical Center, Toledo, Ohio.

The committee responsible for the complete Glass Division program was headed by Robert D. Maurer, Corning Glass Works, as chairman, who was assisted by Clarence Babcock, Owens-Illinois Technical Center, and Harold E. Simpson, Alfred University.

Two highly interesting papers related to various phases of glass technology were presented in the Basic Science Division, under the chairmanship of John B. Wachtman, Jr., National Bureau of Standards, Washington, D. C.

### BASIC SCIENCE

***Detection of Strength Impairing Surface Flaws in Glass.***

*By F. M. Ernsberger,*
GLASS RESEARCH LABORATORIES, PITTSBURGH PLATE GLASS COMPANY.

Sodium-treated borosilicate glass was observed under the microscope during cooling after treatment. Although the Andrade cracks were absent at the end of the sodium vapor treatment, they developed gradually during cooling. When the specimen was reheated in the sodium atmosphere, the cracks disappeared, and a different system of Andrade cracks developed during the second cooling period.

That sodium diffuses into the glass was shown by a gain of weight during treatment which amounted to about 0.5 mg/cm$^2$ in a typical experiment, the absorbed sodium being localized in a very thin film on the surface. The sodium atoms dissociated into ions and electrons, with the latter responsible for the intense brown color of the treated surface. The high concentration of sodium ions changed the surface layer into a glass of lower softening

temperature and higher coefficient of thermal expansion. Cooling developed tensile stress in this layer high enough to cause cracking. When the specimen was reheated, the surface layer expanded, softened, and the cracks healed.

Thus the Andrade cracks were shown to be in general neither identical with the Griffith cracks nor independent artifacts. They were tensile fractures which originated at the weakest points, i.e. at Griffith cracks.

The sodium treatment as an instrument for locating Griffith cracks suffered from the disadvantage that the surface layer was softened, and many, if not most, of the Griffith cracks disappeared by being welded together. This welding may be avoided by choosing a low-temperature method for producing the surface stress. For soda-lime glass, treatment with a molten salt mixture containing lithium ions was suitable.

The stress arose from a partial exchange of sodium ions from the glass for lithium ions from the melt. The stress may be adjusted in magnitude by a suitable choice of melt composition and by the control of time and temperature of contact with the glass. The sites of the Griffith cracks were directly visible. Most of them were star-shaped, probably because they resulted from indentation of the glass by hard particles of dust.

If the glass plate was bent while being moistened, the cracks ran in the direction of the compressive bending stress, i.e. perpendicular to the highest tensile stress in the surface. Accordingly, a simple parallelism existed in all cracks, except in the immediate vicinity of their points of origin.

If the surfaces of the glass plate were removed to a depth of 5-10$\mu$ with aqueous HF, the same lithium treatment failed to cause cracking. If such a surface was damaged by impact, abrasion, etc., the appearance of the resulting cracks was identical with those seen after lithium treatment of glass in its "natural" condition. The Griffith cracks of glass, as far as they can be revealed by the present methods, seem to be due, therefore, to mechanical damage.

### *A New Method of Analyzing Ball Indentation Data to Determine the Distribution of Surface Flaws in Glass.*

*By Eugene W. Sucov,*

GLASS RESEARCH CENTER, PITTSBURGH PLATE GLASS COMPANY.

Microstrength studies using steel ball indenters on flat glass demonstrated that Hertzian ring fractures always occur outside the contact circumference. This phenomenon is not explained by Hertz's theory which predicts maximum tensile stress and therefore maximum probability for fracture at this circumference. To explain this discrepancy the paper assumed that the fracture origin was the worst Griffith flaw in the region surrounding the contact circle.

Analysis of the manner in which the Hertzian stress pattern grew with increasing loads showed that the maximum stress at any given load was proportional to the contact radius, $a$, for that load. When fracture occurred at some radial distance, $r$, owing to a certain stress, the annular area between $r$ and the contact radius corresponding to that stress was tested for flaws and the worst one located at $r$. This testing procedure was described by a

FIG. 2. Newly inducted officers and trustees of the American Ceramic Society. Seated, left to right: George H. Spencer-Strong, Pemco Corp., president; Jack Nordyke, Hammond Lead Products, Inc., president-elect; Eugene C. Clemons, Cannelton Sewer Pipe Co., and Andrew Pereny, Pereny Equipment Co., secretaries. Standing, left to right: Karl Schwartzwalder, AC Spark Plug Division, General Motors Corp., trustee; Clair R. Oberst, Industrial Ceramics Products, Inc., treasurer; and W. J. Smothers, Ohio Brass Co., trustee.

Not in picture are Frederick H. Norton, Massachusetts Institute of Technology, vice president; Henry A. Sulens, Cesco Division, Ferro Corp., and Richard J. Galvin, Sheffield Brick & Tile Co., trustees.

Pascal distribution which stated that, in examining identical boxes (unit areas $A_1$) in succession, the probability of finding one success (flaw of critical size for fracture) after $k$ failures was given by:

$$q^k p$$

where $p$ is the probability of finding success in any one box, and

$$q = 1\text{-}p.$$

To obtain the best estimate for $p$, the Principle of Maximum Likelihood was used and resulted in

$$p = n/(n + \Sigma k)$$

where $n$ = total number of successes. The mean density of flaws per square mm., $d$, having a range of critical Griffith depths, were determined from the relation:

$$d = n/(n + \Sigma k)A_1$$

By a repetition of this analysis for many ranges of flaw depths, the distribution of density as a function of flaw depth was obtained.

Monday Afternoon Chairman: Robert D. Maurer, Corning Glass Works, Corning, New York.

***Internal Friction of Progressively Crystallized Glasses.***

*By D. E. Day,*

PITTSBURGH PLATE GLASS COMPANY

and *Guy E. Rindone,*

ASSISTANT PROFESSOR, DEPARTMENT OF CERAMICS, PENNSYLVANIA STATE UNIVERSITY.

*Presented by Mr. Day*

The paper discussed the measurement of the internal friction of partially crystallized $Li_2O.2.75\ SiO_2$ glass fibers, containing from 0 to 78 per cent lithium disilicate crystals. Homogeneous and heterogeneous nucleation techniques provided partially crystallized fibers of sufficient strength to be used in a torsion pendulum. The 2 internal friction peaks which were present in the $Li_2O.2.75\ SiO_2$ glass were gradually destroyed with the progressive crystallization of the lithium disilicate. In addition a new relaxation, which had first appeared as an inflection in the background of glass fibers nucleated at 500°C. for more than 4 hours, became a pronounced peak in the partially crystallized glasses. Heat treating the glass fibers at different temperatures without leading to crystallization changed the height and temperature position of the low temperature internal friction peak but did not affect the other peak.

***Volatility of Lead-Borate Systems.***

*By Chikara Hirayama,*

WESTINGHOUSE RESEARCH LABORATORIES, PITTSBURGH, PENNSYLVANIA.

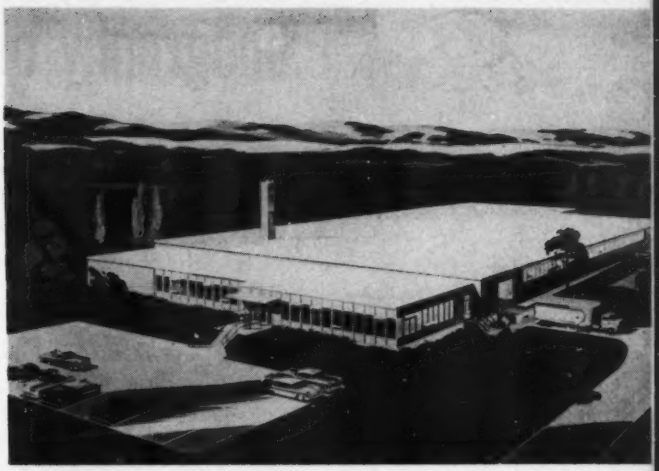
The relative volatility of some lead-borate glass systems was measured and a comparison with lead silicate systems made. The volatility of the materials was measured at temperatures of 750° to 850°C. and pressures down to 0.025 mm. Hg. The dissociation pressure of PbO at different temperatures was calculated from the most recent thermochemical data, with the stability of lead oxide systems being considered in view of this calculation. A thermodynamic consideration of the volatility of lead-borate systems was also discussed. It was shown that the lead borate systems are less volatile than the corresponding silicates. The true index of volatility is the initial rate obtained by extrapolation of the log $v_t$ vs. $t$ relationship to zero time.

**(To be concluded next month)**

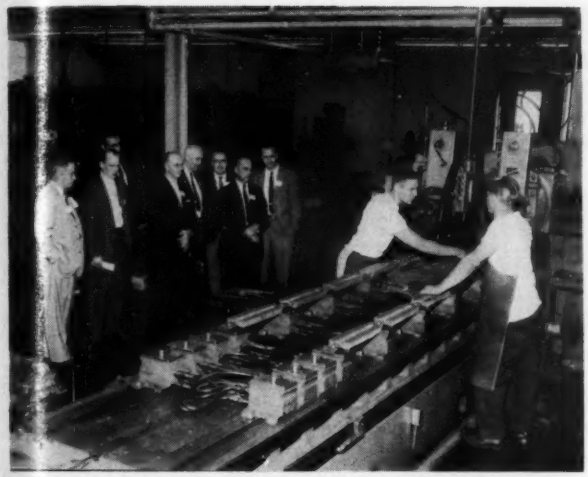
FIG. 3. New Fellows of the American Ceramic Society. Standing, left to right: Walter H. Gitzen, Alcoa Research Laboratories; Neil N. Ault, Norton Co.; Theodore A. Randall, State University of New York College of Ceramics at Alfred University; Osgood J. Whittemore, Jr., Norton Co.; Robert F. Patrick, Pemco Corp.; Alexis G. Pincus, General Electric Research Laboratory; James A. Crookston, A. P. Green Fire Brick Co.; James F. Wygant, Standard Oil Co.; John E. Marquis, Pemco Corp.; and Edwin Ruh, Harbison-Walker Refractories. Seated, left to right: George J. Lane, Edgar Plastic Kaolin Co.; Willis G. Lawrence, State University of New York College of Ceramics at Alfred University; J. Sheldon Carey, University of Kansas; Alan T. Prince, Mines Branch, Department of Mines and Technical Surveys of Canada, Ottawa, Ont.; Floyd A. Hummel, College of Mineral Industries, Pennsylvania State University; Harold T. Smyth, School of Ceramics, Rutgers, the State University; Charles J. Phillips, Theodore A. Randall, Department of Design, State University of New York College of Ceramics at Alfred University.

Not present when this picture was taken were William J. Knopp, University of California at Los Angeles, and Wilhelm H. Eitel, Institute of Silicate Research, University of Toledo.

# 1960 Overmyer Iron Clinic



New Overmyer Mould Co. factory, Greensburg, Pa., for the manufacture of glass moulds. Plant has 41,000 sq. ft. of manufacturing space.



Viewing mold planing equipment in operation are left to right: James Kindelan, Greensburg plant manager; John Russell, and Robert Scott, Knox Glass; Otto Samuelson, Thatcher Glass; Harold Youkers, Knox Glass; Richard Pershing, Overmyer, sales; Harold Knight, and Paul Murdock, Knox Glass.

● THE 1960 OVERMYER IRON CLINIC at Greensburg, Pa., June 9, was as interesting as the eight which preceded it and its value was increased by the opportunity to tour Overmyer Mould Company's new Greensburg plant. As far as can be determined it is the only factory ever planned and built exclusively to manufacture molds for the glass industry. The former facilities at Greensburg were purchased from the original Greensburg Mould and Machine Company in 1935. Their capacity was expanded to the limit with the advent of bottle molds in 1951, clearly illustrating the need for new and larger quarters.

The plant, 41,000 square feet of manufacturing space containing highly automatic equipment for the mold manufacturing operations, was toured enthusiastically by over 180 glass manufacturing visitors from this country and abroad. Outstanding, in addition to the high degree of automation, is the generous amount of working space provided for each man.

## Technical Program

Lowell Roesner, Overmyer Mould president, welcomed the visitors and introduced Earl R. Flatter, vice president of the company, who narrated a film strip of the current mold metals research activities at the Winchester, Ind., and other plants.

Included in the film was a small glass furnace which runs continuously day and night. Into its glass batch various grades of iron are immersed to determine their suitability for glass manufacturing. The furnace's purpose is to offer actual glass factory operating conditions in order to help solve many glass manufacturing problems, improve mold metals, and provide information for specific recommendations on the care and maintenance of mold equipment after it enters production.

The furnace operations seemed to receive the highest priority among questions from the floor at the end of the program, specifically, as to the type of tests to be conducted. Although each question was answered separately, the summation was that each experiment would be based on actual operating problems referred to Overmyer by its customers.

The next step in the program was a discussion of mold metals by Newton Davis, Overmyer chief metallurgist. He began with the important role of the air-cored transformer or induction furnace in the production of mold metals and described the metals produced by the company's electric furnace melting department, and the heat treat and annealing process.

Until 1925 the induction furnace was confined to small sizes, then commercially large and efficient generators became available for production size units and production usage increased rapidly. The device enables a wide range of metals to be successfully produced because non-ferrous metals as well as cast iron and steel can be melted in the furnace. The company's electric furnace melting department is presently manufacturing six mold metals.

(*Continued on page* 414)

# Bibliography on Glass Structure

*In 1955 the Reasearch Committee of the American Ceramic Society, under the Chairmanship of Dr. Louis Navias, initiated a program dealing with the role of the glassy phase in ceramics. This subject was chosen as being one which was involved in all types of ceramic products and therefore of interest to most all the divisions of the American Ceramic Society.*

*The Basic Science Division, since it is not associated with any particular ceramic product such as whitewares, refractories, etc., decided its contribution should deal with the structure of glass. It was felt that a comprehensive bibliography on the subject would make a useful contribution to the literature.*

*During the years 1955-1958, the bibliography was assembled. Acknowledgment is made of the assistance given by Norbert J. Kreidl of the Bausch and Lomb Optical Company and by Neill M. Brandt, who, at that time, was with Mellon Institute. In 1958 further assistance was given by P. D. S. St. Pierre, S. Zerfoss, H. Huff, W. R. Prindle and P. Sutton in bringing the survey up to date and making it more complete.*

*The bibliography in its present form consists of 420 references with 292 contributing authors. It is hoped that its publication will make available a reference source on the subject of "Glass Structure" that is useful, complete and easily available.*

*The encouragement of my associates, the assistance of the above mentioned persons and the gentle prodding of Chairman Navias have been appreciated and have been necessary to complete the job. The publishing arrangements were made by T. J. Planje, presently Chairman of the Basic Science Division Research Committee.*

—W. G. Lawrence, Chairman Research Committee, Basic Science Division, American Ceramic Society, 1955-1959

*This Bibliography on Glass Structure, which begins in this issue, will appear monthly throughout early next year. At that time, complete reprints will be available, provided there is sufficient interest. Please send inquiries as soon as possible to: Reprint Dept., THE GLASS INDUSTRY, 55 West 42nd Street, New York 36, N. Y.*

**1. Sir David Brewster**

"Structure and Optical Characteristics of Iridescent Glass," Br. Assoc. Rep. 2, 5-6 (1840); 2, 11 (1859); 2, 9-12 (1860); Abs. Edinburgh Roy. Soc. Trans. 23, 193 (1861).

**2. Noel Heaton**

"The Structure and Optical Characteristics of Iridescent Glass," J. Soc. Arts, 55, 468-81 (1907).

**3. C. E. Guye and S. Vasileff**

"Internal Friction of Glasses," Arch. Sci. et Nat., 37, 214-25, 302-23 (1914).

A frequency peak of 15.5 Kg. cal/mol was observed and is equal to the activation energy of Na diffusion.

**4. G. Quincke**

"Structure and Properties of Glass," Ann. Physik, 46, 1025 (1915); 48, 113 (1915).

**5. W. E. S. Turner**

"The Nature and Constitution of Glass," J. Soc. Glass Tech., 9, 147-66 (1925); Chem. Abs. 20, 3787 (1926).

Silicate Glass, a rigid solution, may be considered a mass of $SiO_2$ threads soaked in the silicates or their dissociation products. The existence of certain compounds as $Na_2O \cdot 2SiO_2$ has been shown in glass and other solutions while others such as $Na_2O \cdot CaO \cdot 6SiO_2$ have been indicated. It is probable that the molecular weight of fluid glass is high at temperatures from 1200-1450°C.

**6. G. S. Parks and H. M. Huffman**

"Glass as a Fourth State of Matter," Science, 64, 363-4 (1926).

With n-PrOH, the softening or melting of the glass takes place rather sharply between 90 and 102°K and there is an abrupt 80% increase in heat capacity, as well as an increase in volume. These considera-

tions among others point to glass as the fourth state of matter distinct from liquid or solid but having some of the properties of both (random arrangement, but rigid bonding so that increase in heat capacity is similar to heat of fusion of crystals).

**7. W. Rosenhain**

"Structure and Constitution of Glass," J. Soc. Glass Tech., 11, 77-97 (1927).

Rosenhain adopted the idea of definite limiting interatomic distances in amorphous material. Interatomic forces are assumed to be vectorial, with linkages attending to form certain definite angles with each other, linkages other than those forming distortions which imply storage of energy. Thus even in irregular assemblies of atoms there are tendencies toward some aggregation though most of the linkage bonds are unsatisfied. Amorphous matter is less homogeneous than crystalline and the number of atomic linkages is much smaller. There is, therefore, no definite breaking temperature of these linkages to permit melting as in a crystal. Glass is not a true viscous liquid below 700° but rather is visco-elastic. In the simpler forms it consists mainly of an assembly of independent atoms while in the more complex types heterogeneous congeries probably would occur.

**8. R. W. G. Wyckoff and G. W. More**

"X-Ray Diffraction Measurements on Some Soda-Lime-Silica Glasses," J. Soc. Glass Tech., 9 (35) 265-67 (1925); Cer. Abs. 47 (1926).

Some experiments were undertaken as preliminary survey of an extensive system of glasses studied by Morey and Bowen. Their purpose was to study the nature of glasses themselves and the mechanism of the quantitative explanation of their x-ray patterns. It was found that the diffraction patterns of these glasses did not conform in all cases to previous experience. It was found however that a close relationship exists between the diffraction patterns of these glasses and certain aspects of the melting point diagram. Explanations of the various phenomena observed have been deferred until there is an opportunity to examine a larger number of glasses.

**9. F. Eckert**

"Some Remarks on the Constitution of Glass," J. Soc. Glass Tech., 9, (35) 267-72 (1925); Cer. Abs. 48 (1926).

The problem of the constitution of glass has often been obscured because the question of the state of aggregation has been confused with that of the constitution. The author discusses for the most part the dependence of glass upon the heat treatment for the explanation of its properties.

**10.**

The Constitution of Glass, A London Symposium, Chem. Age 12 (311) 527 (1925); Cer. Abs. 302, (1925).

A brief resume of papers presented at the main meeting of the Society of Glass Technology included: "Glasses as Supercooled Liquids" by G. Tammann; "The Constitution and Density of Glass" by A. Q. Tool and E. E. Hill; "The Ternary System Sodium-Metasilicate Calcium-Metasilicate Silica" by G. W. Morey and N. L. Bowen; "The Viscosity and Allotropy of Glass" by H. L. Chatelier; "The Structure of Quartz and Silica" by W. Bragg; "X-ray studies of Soda-Lime-Silica Glasses" by G. W. Morey and R. W. G. Wyckoff; "The Viscosity of Glass" by Z. H. Stott.

**11. A. Q. Tool and E. E. Hill**

"On the Density and Constitution of Glass," J. Soc. Glass Tech., 9 (35) 185-207 (1925); Cer. Abs. 15, 47 (1926).

The fundamental hypothesis on which this paper is based is that under proper cooling conditions certain processes or reactions practically reversible without drastic treatment and involving some or all of the constituent molecules of a glass shall advance in such a way that other possible and disturbing processes often associated with cooling and with treatments at temperatures above the annealing range are prevented.

**12. N. N. Smirnov**

"Microstructure of Glass," Trans. State Expt. Inst. Silicates (Moscow) No. 23, 5-29 (1926).

The conditions responsible for the appearance of various crystalline products in glass as indicated by a number of these are: $CaSiO_3$ in the form of needles in the monoclinic systems of wollastonite crystallizes at 1000° and in the form of hexagonal plates at the very high temperatures. Both of these forms are characteristic for glass with a high Ga content. Other crystals which form from glass in the process of devitrification are discussed including silica, in the form of tridymite and cristobalite. The observations of Smirnov show that these silicates belong not only to wollastonite but other compounds of the type $3CaO \cdot 2SiO_2$ and $2CaO \cdot SiO_2$.

**13. O. Knapp**

"New Views on the Chemical Constitution of Glass," Chem. Rundschau Mittleuropa u. Balkan, Sept. 30, P. 155 (1927); Cer. Abs. 824 (1928).

Glass was considered most probably to be, chemically, a silicate in mutual solution in free acids and bases. From the physico-chemical point of view it was suggested that those substances were to be considered as glasses which possess at the temperature prevailing below the equilibrium curve a liquid phase corresponding with the field above the curve.

**(To Be Continued in August)**

RARE EARTH FLUORIDE * DIDYMIUM FLUORIDE
YTTRIUM SALTS * CERIUM HYDRATE
CERIUM OXALATE * LANTHANUM OXALATE
LANTHANUM OXIDE * PRASEODYMIUM OXIDE
PRASEODYMIUM OXALATE * NEODYMIUM SALTS
CERIUM OXIDE * RARE EARTH OXIDE
RARE EARTH CHLORIDE * THORIUM SALTS
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*Mr. Horton, who holds a degree in chemistry from Brown University, formerly held varying assignments in textile research and development with Owens-Corning Fiberglas Corporation.*

*He is a member of The Society of the Plastics Industry, Society of Plastics Engineers, American Chemical Society, American Society for Testing Materials, and Chemists' Club. He has written numerous papers and holds several patents in the field of fiber glass technology.*

# INDUSTRIAL FIBER GLASS FABRICS
## Quality Control, Testing, and Specifications

*by* ***Richard C. Horton*** J. P. STEVENS & COMPANY, Inc.

● THE AIM OF ANY QUALITY CONTROL PROGRAM is to assure the user of the product that he will receive a dependable, uniform material. Ever since the inception of the fiber glass-reinforced plastics industry during World War II, the textile industry has realized the need for control of its manufacturing conditions in order to deliver a consistent piece of fiber glass fabric. Obviously, this has not been too easy because of the newness of the materials.

Obtaining consistent quality in any component of a fiber glass-reinforced plastic is complicated by the fact that the composite laminate is a result of the combination of a diversity of basic materials—resin, catalyst, filler, mat, pigments, woven roving, fabric—under a wide range of conditions. For example, a recent study for the U.S. Air Force by the Owens-Corning Fiberglas Corp. indicated that it was possible to get over 600 instances of process variables affecting one property of a fiber glass fabric reinforced laminate. As a result of the complexity of evaluating one component of the laminate and the need for high reliability in any basic structural material, the weavers and finishers of industrial fiber glass fabrics have worked hard to set up the necessary controls, standards, and specifications, and the technical people and laboratories to implement them.

We realize that every textile process has a basis for its being, in a good scientific principle, and that the progress of the industrial fiber glass fabric business depends upon the accurate control and measurement of the properties of the fiber glass yarn, the greige goods, and of the finished fabric. I would say that, without question, the fiber glass fabric segment of the textile business supports the most modern laboratories with the most extensive range of testing apparatus, manned by skilled technologists and technicians, as compared to any other segment of the textile business today. Of course, all of the testing is done in accordance with procedures set up as a result of close technical cooperation with our customers, suppliers, various government agencies, and associations such as the American Society for

Presented at Industrial Glass Fabric Design Engineering Symposium, May 1960, sponsored by Owens-Corning Fiberglas Corporation.

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Testing Materials and the National Electrical Manufacturers Association. In common with all new materials, it has taken time and experience to develop the procedures and to amass good test data.

The raw material with which the weaver is concerned is fiber glass yarn. Acceptance inspection of the yarn at the weaver's plant is a necessary part of manufacturing. Statistical sampling procedures are set up to check the weight of the yarn versus its length, the organic content, the strength, and the twist. In addition, each tube of yarn is inspected visually before being put into process for excessive filament breakage, surface dirt or oil contamination, and for proper labeling. We believe that the best protection against the acceptance of defective yarn is having the yarn made right in the first place. That this philosophy is accepted by the yarn producer is certainly evident in the greatly improving levels of yarn quality and the great amount of time and money being devoted constructively to fiber glass yarn control and improvement.

The methods for testing the physical properties of continuous filament and staple fiber glass yarns are covered in ASTM Test Method Designation D 578 - 52 entitled "Standard Methods of Testing and Tolerances for Glass Yarns." Copies of this and other ASTM specifications relating to fiber glass and plastics can be obtained from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

Each weaver carefully controls each part of his process to insure fabric uniformity. Each operation—quilling, beaming, warping, slashing, weaving—has its own specific controls. One of the most important is control of tension, because of the lack of extensibility of fiber glass yarns as compared to organic fiber yarns. The great effort in the control of tension of each end in a fiber glass weaving plant sets it apart from a plant weaving any other fiber.

As the fabric comes from the loom and before it has been finished, it is commonly called grey or griege goods. The thickness of the fabric, its width, weight, count, strength, and organic content are all important properties which are measured and controlled.

The tolerances and test methods for most industrial fiber glass grey fabrics are covered in detail in Military Specification MIL-Y-1140C entitled "Yarn, Cord, Sleeving, Cloth, and Tape-Glass." In addition, ASTM "Testing and Tolerances for Woven Glass Fabrics" is a good reference. A group in the National Electrical Manufacturers Association (NEMA), 155 East 44th St., New York 17, N.Y. is preparing a specification for light weight grey fiber glass fabrics.

It is important that a differentiation is made between the properties of the grey of off-loom fabric and the properties of a heat-cleaned and finished fabric.

The basic specification relating to finished fiber glass fabric for use with polyester resins is Military Specification MIL-F-9084A entitled "Fabrics, Woven Glass, Finished, for Plastic Laminates." A more complete review of properties and tolerances for low pressure laminates reinforced with finished fiber glass fabrics can be obtained in Military Specification MIL-P-8013C entitled "Plastic Materials, Polyester Resin, Glass Fiber Base, Low Pressure Laminated."

The qualification procedure for finishes to be applied to fiber glass fabrics for low pressure laminates is covered in Military Specification MIL-F-9118 entitled "Finish, For Glass Fabric."

In addition to these military specifications relating to finished fiber glass fabric, a group in ASTM has recently completed work on a proposed specification for finished fabric. This specification is presently up for review and acceptance by ASTM. Each of the fabric suppliers will have copies available when it is accepted.

The specifications for high-pressure laminates reinforced with finished fiber glass fabrics have been the concern of NEMA. A wide range of specifications covering the use of fiber glass fabrics in a number of resin systems is available from NEMA.

A review of any of the specifications for finished fiber glass fabrics will indicate that the best way to study, test, and approve a finished fiber glass fabric is to construct a standard laminate and test it. Each of the major suppliers of finished fiber glass fabrics maintains a completely equipped reinforced plastics laboratory and supplies certifications to the proper specifications when needed.

In addition to the specifications relating to finished cloth, work is underway on specifications for woven roving, an important new reinforcement. Military Specification MIL-C-19663(Ships) entitled "Cloth, Glass, Woven Roving, For Plastic Laminate" is the first of many which I am sure will evolve. A group in ASTM is working on this problem too.

Every person concerned with design of fiber glass reinforced plastics should familiarize himself to as great extent as possible with the specifications which have been prepared and the changes as they become available. I would certainly suggest that a very valuable asset would be a reference file of specifications relating to fiber glass. A word of warning, though. Most military specifications are generally in short supply. Information relating to most military specifications relating to fiber glass fabrics can be obtained by writing to: Commander, Wright Air Development Division, Attention SCXP, Wright-Patterson Air Force Base, Ohio, Commanding Officer, Naval Aviation Supply Depot, 70 Robbins Avenue, Philadelphia 11, Pa., Commanding General, Philadelphia Quartermaster Depot, 2800 South 20th Street, Philadelphia 45, Pa.

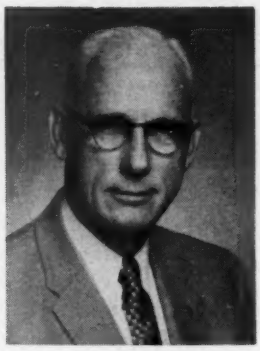
Detailed test methods are generally covered in Federal Specifications, not in Military Specifications. The Military Specification will generally refer to a Federal Specification test method. Information concerning the availability of such specifications, such as Federal Specification L-P-406b entitled "Plastics, Organic: General Specifications, Test Methods," can be obtained from:

(*Continued on page* 415)

# NEWS
## IN THE GLASS INDUSTRY

### Personalities...

Ralph V. Reisgen



John M. Fisher

Robert M. Hainsfurther

Lee A. Kleeman

**Ralph V. Reisgen**

Will retire August 1st, as vice president of glass manufacturing for Pittsburgh Plate Glass Company. He has served in glass manufacturing operations for 40 years. John M. Fisher director of engineering, will retire after 43 years' service.

Robert M. Hainsfurther, general manager of plate glass factories, becomes vice president of production, glass division, effective August 1, and William C. Oberlin, chief engineer, glass division, will become director of engineering. He will be responsible for the administration of the general office engineering and glass division purchasing departments.

**Cecil E. Ballard**

District manager with the Commercial Container Division, Ball Brothers Company, Muncie, Ind. His headquarters will be in the firm's new glass container plant, Asheville, N.C.

**H. B. Dubois**

Appointed director of marketing for the Feldspar Corporation, Spruce Pine, N.C.

**William M. Raynor**

General sales manager, Foote Mineral Company. He has been with the organization since 1942 and has been director of purchasing since 1956.

**William C. Drohan**

Supervisor of product engineering, Laboratory Glassware Sales Department, Corning Glass Works. He was a product specialist for the department prior to this appointment and has been with the company since 1950. John W. Kopko succeeds him as product specialist.

**Lee A. Kleeman**

Has joined the staff of The Glass Container Industry Research Corporation, New Castle, Pa., as a ceramic engineer. He will assist in coordinating some of the various research projects now in progress and those proposed by the group. Kleeman was formerly with Harbison-Walker Refractories Company.

**Dan Kaufman**

Promoted to supervisor of inorganic research, Research Division, Wyandotte Chemicals Corporation. He will assume additional responsibilities in the coordination and planning of research projects in the inorganic area.

**K. Russell Knoblauch**

Appointed market sales manager, Industrial Products Group, Minneapolis-Honeywell Regulator Company. The Industrial Products Group includes the Brown Instruments and Rubicon Division, Philadelphia; Valve Division, Fort Washington, Pa.; Industrial Systems Division, Beltsville, Md.; Heiland Division, Denver; and Fall River, Mass., Division.

**John D. Mink**

Assistant manager, Dunkirk, Indiana, glass plant of Armstrong Cork Company. Albert J. Diener is general plant superintendent and Michael J. Urmon, production superintendent. The appointments are a result of a major expansion at the plant which increased production capacity by 50 per cent and employment from 200 to approximately 1,000 persons. The plant produces glass containers for food, beer and beverage, wine and liquor, toiletry and cosmetics, drug and pharmaceutical, and household and chemical industries in the Mid-West.

**Daniel T. Hardy**

Named manager of Libbey-Owens-Ford Glass Company's Shreveport La., factory, succeeding John H. Goodwillie, resigned. He has been with the company since 1933, and in 1942 was transferred to Shreveport as office manager, becoming production manager in 1944 and assistant plant manager three years later.

Curtis A. Mewbourne, formerly chief machinery operator in the drawing department, is now general superintendent of furnaces, machines and lehrs.

**Saiyid M. Naqvi**

New research staff member, contract research department, Wyandotte Chemicals Corporation. Naqvi received his B.S. degree from the University of Sind in Karachi, Pakistan; his Ph.D. degree from the Illinois Institute of Technology.

Other new staff members are Bernard A. Merkl, graduate of University of Detroit; Donald E. Witt, graduate Wayne State University; and George Roley, graduate of Michigan College of Mining and Technology, and Iowa State College. They will be engaged in research and development projects relating to programs of the U.S. Department of Defense.

**Stewart W. Schulmeyer**

Staff manager of plastic reinforcement sales for Johns-Mansville Sales Corporation's glass textile section. James J. Secor, Jr., replaces Mr. Schulmeyer as staff manager for electrical and industrial yarn sales. Regional promotions in the glass textile section include Richard C. Schofield, transferred from the Southeastern states to Los Angeles where he will direct sales in Southern California and Arizona, and Ralph G. Cox who will replace him in the Southeastern area.

**American Potash & Chemical Corp.**

Has chosen James H. Rhodes and Company, Chicago and Long Island City, to market the corporation's glass polishing compounds in the United States. S. Becker Treat, formerly manager of polishing products at American Potash has joined Rhodes as vice president in charge of glass polishing sales and research.

Present polishing distributors will be maintained under the agreement, and Rhodes Company will service the polishing distributors and direct accounts through their technical sales force. American Potash will continue to handle export sales of the compounds which are produced by the corporation's Lindsay Chemical Division, West Chicago, Ill.

Lindsay's optical research laboratory will continue its program of product development, quality control and technical assistance to the production department. Dr. Mark M. Woyski and Dr. Walter L. Silvernail will work closely with Rhodes Company personnel in all phases of the association.

**Hugh M. McClellan**

Distributor district manager in New York for Libbey-Owens-Ford Glass Company. Prior to his new appointment he served as industrial district manager in Kansas City.

**Charles S. LaFollette**

Manager of marketing research, Corning Glass Works. He joined the company in 1955 as an accountant at the Central Falls, R.I., plant.

**Robert G. Dow**

Field salesman for the Chicago branch sales office of Diamond Alkali Company, succeeding the late H. T. Woolacott.

**H. J. Paulus**

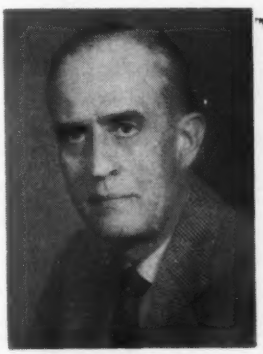
Formerly manager of building products sales, Fiber Glass Division, Pittsburgh Plate Company, has been appointed manager of reinforcement marketing. A. C. Pecora has been named manager of insulation marketing and E. M. Penney, and W. T. Irwin are managers of industrial textile marketing and transportation marketing, respectively.

**John Blaine**

Named tank superintendent, Libbey-Owens-Ford Glass Co., succeeding James E. Mambourg, at the Shreveport, La., window glass plant. Laverne McCallister will become assistant tank superintendent.

The company also appointed three new district office managers: Edwin C. Rogers, Indianapolis; William E. Black III, Denver; and John F. McDaniel, Seattle.

A. C. Boldemann and W. Z. Frederick Walter have been transferred to Los Angeles and Richmond, Va., respectively, and James E. McHenry, Jr. has been tranferred as regional sales promotion manager from Dallas, Tex., to L-O-F's New York office. He is succeeded in Dallas by Glenn T. Dunn, Jr.



S. Becker Treat

Lyle Holmes

**Lyle A. Holmes**

Appointed manager of U.S. sales for American Nepheline Corporation, Columbus, O. Prior to his appointment he was sales engineer for Great Lakes Foundry Sand Company, the former U.S. sales agents for American Nepheline.

**Gerald S. Haney**

Named manager of sales services, Hazel-Atlas Glass Division, Continental Can Company. Mr. Haney will direct, implement and execute all administrative activities of the sales department and will be directly concerned with the functions of product sales, pricing, market research and sales analysis.

## Obituaries...

**Herman R. Urbach**

Herman R. Urbach, treasurer and general manager of the O. Hommel Company, Carnegie, Pa., died suddenly at his home, June 9, 1960. He had been with the company for 57 years.

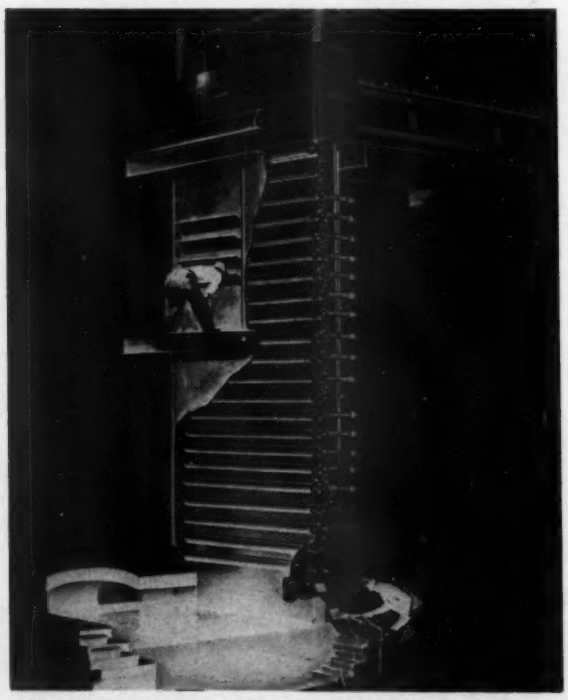
## Companies...

**United States Borax & Chemical Corp.**

And Lithium Corporation of America, Inc., have established a cooperative arrangement for the promotion and sale of lithium compounds in the United States and certain adjacent foreign markets through the appointment of U.S. Borax as sales agent. The sale of lithium compounds used by the ceramic and glass industries is covered by the agreement, as well as the joint promotion and development of other industrial uses for lithium.

**Flat Glass Jobbers Association**

Is holding its 1960 convention, July 10th-15th at the Edgewater Beach Hotel, Chicago. Alain du Breil, vice president and sales coordinator, and Albert J. Bundy, director of market research, both of American Saint-Gobain Corporation, will conduct a seminar session on the subject of "Flat Glass Consumption in the U.S.A.—An Uncritical View of Imported Glass." Other seminar sessions and general sessions are included.



Pittsburgh Plate Glass Company's new glassmaking process for super sheet glass. Molten glass is formed into sheets in a straight vertical draw without being touched by any mechanical device that will mar its surface. Company developed the Pennvernon drawing machine shown above.

**Owens-Illinois Glass Co.**

Has enlisted the aid of three leading glass-melting consultants because of increasing orders requesting installation of the company's patented glass bubblers for glass melting tanks and forehearths.

The consultants, Robert W. Hopkins, president, Glass Technicians, Inc., Hamilton, O.; Paul C. B. Allen, Toledo, O.; and K. C. Carnes, vice president, Toledo Engineering Company, Inc., Toledo, will work with Owens-Illinois in recommending and supervising bubbler installations for the licensees.

The bubblers are installed to reduce stones, seeds, and cords in the melted glass and to increase the pull of the glass tank by introducing gaseous bubbles of controlled size at certain critical regions in the melting and refining areas of the glass tank.

**Shatterproof Glass Corp.**

Began construction on a modern two-story administration building adjacent to its Detroit manufacturing plant. The new building will contain 18,000 sq. ft. of floor space.

One of the world's largest independent manufacturers of auto replacement glass, Shatterproof glass began operations in 1922 with three employees; today the company has over 500 employees.

**GCIRC**

The Glass Container Industry Research Corporation held its annual membership meeting at the Greenbrier, While Sulphur Springs, W. Va. Finley B. Hess, president, Brockway Glass Company, Inc., was re-elected chairman of the board and R. R. Board, vice president, Foster-Forbes Glass Company, was re-elected treasurer.

William Green, president, Thatcher Glass Mfg. Company, and John Faris, vice president, Laurens Glass Works, were re-elected for new terms as trustees. Other trustees include Frank H. Wheaton, Jr., president, Wheaton Glass Company; John R. Harkness, president, Fairmount Glass Works, Inc.; and Dr. A. L. Johnson, president, GCIRC.

GCIRC does not have research facilities of its own but assigns research topics selected by its technical committee, to laboratories and organizations capable of handling the subject matter.

The committee is headed by Dr. Roy Arrandale, vice president, Thatcher Glass Manufacturing Company, Inc., and at present has some ten projects under study.

**Corning Glass Works**

Producing aircraft dial blanks of photosensitive glass that can be precision patterned by chemical machining. They are delivered to the aircraft dial manufacturers as chemically cut and patterned blanks and then the numbers and graduations are applied. Photosensitive glass is also used in such electronic products as printed circuit boards, fine mesh screens, and dielectric spacers.

**Alfred University**

Received a $5,485 grant from The National Science Foundation for an undergraduate research participation program during the summer.

Dr. Charles H. Greene, chairman of the glass technology department, will direct six students on special research projects in glass. They will receive stipends of $600 each, and the remainder of the grant will be used to meet operational costs.

**Glass Sidewalk**

With a 96-foot span, ten-foot width, and a thickness of two inches has been installed in Reno, Nev.

The sidewalk consists of more than 290 laminated safety glass blocks mounted on I-beams to permit under-lighting by more than 2,500 feet of white neon tubing. Special bonding agents cushion each block against contraction and expansion caused by variations of day and nighttime temperatures.

Amerada Glass Corporation, Chicago, produced 18 tons of glass for the blocks. Pictures of pioneer western scenes on one third of the blocks have been silk-screened on the underside of the top layer of glass. A plastic interlayer, supplied by Monsanto Chemical Company's Plastics Division, is laminated between the two sheets of glass in each block. This plastic interlay is commonly used in laminated safety glass for automobile windshields, decorative glazing and industrial safety applications, and as a means of solar energy control.

**All-glass, illuminated, illustrated sidewalk fronting Harold's Club Reno, Nev., is 96 ft. long, 10 ft. wide and 2 in. thick. More than 2900 laminated safety glass blocks, a third of which are illustrated with paintings of pioneer western scenes, are illuminated at night by more than 2,500 ft. of white neon tubing. Surface is sandblasted to prevent slipping in wet weather.**

**Carolina Mirror Corp.**

Announced a new development in mirror manufacturing, a baked-on enamel backing. It is said to offer the highest chemical resistance of any mirror coating yet developed, resisting moisture, salt spray, and chemical fumes. It can be cut, beveled, or drilled without flaking, and is not affected by drill lubricants or turpentine.

**General Electric**

Embarking on an expansion program designed to boost production capacity of its Silicone Products Department to 1963 demand levels with emphasis on the production of newly-developed products. The program will cover a 24-month period with with an investment of several million dollars in new buildings, equipment and processes.

Manufacturing facilities for silicone fluids, dispersions, emulsions and specialty products are under construction now and will add 15,000 sq. ft. to the company's Waterford, N. Y. silicone plant. The new fluids building will increase the plant's manufacturing buildings to seven and total facilities to 15 major buildings. The Waterford operations produce emulsions, greases, specialties and silicone chemicals.

**Information for Industry, Inc.**

Has covered more than 63,000 chemical patents issued by the U.S. Patent Office, from 1953 through March 1, 1960, in the company's publication Uniterm Indexes. Over 2,500,000 technical references contained in the patents are indexed and available to industrial, governmental and educational organizations in connection with their basic and applied research, new product development, market research, and patent and licensing work. The organization intends to compile annual indexes of chemical patents for the years back to 1950 and will issue every other month accumulative indexes of new chemical patents granted. The indexes include the fields of glass, glass fibers, silicones, coatings, metallurgy, electrochemistry, and atomic energy.

**Brockway Glass Co., Inc.**

Filed a registration statement with the Securities and Exchange Commission which covered a proposed public offering of 162,000 shares of common stock at a par value of $5 per share. Of these shares 130,000 are to be sold for the company and the balance for the account of selling stockholders. Lehman Brothers and Blyth & Co., Inc., will manage the underwriting.

Sales proceeds of the shares offered by the company will be applied toward the construction and equipping of a new glass container plant at Rosemount, Minnesota. Estimated cost is $5,750,000. The balance will be paid from the company's funds.

Brockway also increased its regular quarterly dividend on common stock from 15¢ to 20¢ a share. The increase was paid on June 30th.

# INVENTIONS AND INVENTORS

## Glass and Wool Fiber

*Spinning amorphous glass fibers from a viscous aqueous system. Patent No. 2,886,404.* Filed April 26, 1957. Issued May 12, 1959. No sheets of drawings; none reproduced. Assigned to Montecatini-Societa Generale per l'Industria Mineraria e Chimica by Jayanti Dharma Tejt.

This invention is particularly concerned with that approach by which a substantially dehydrated glass structure of the fiber is achieved by the combination of synersis, diameter-reduction, and stretching of the stream which forms the fiber said steam initially being a viscous aqueous system partaking of the nature of an alkaline silicate solution containing not only coloidal silicate particles but also oxygen containing compounds of at least one metal, the oxides of which belong in the long established group of metal oxides which have been incorporated in significant amounts in the various formulations of fused transparent silicate glass, and sometimes known as the non-alkaline glass-component oxides.

In order to form strong glass fibers from streams of aqueous siliceous systems, solidification must be postponed until the siliceous material has a density of the general magnitude of the fused, anhydrous composition. After solidification, the surface of the fiber can be modified, and water can be removed from the surface, or even from the interior of the fiber, but a significant portion of the control of the density and tensile strength of the filaments must be achieved prior to solidification. Dehydration of the interior of the filament subsequent to solidification, even when it is accompanied by some shrinkage and increase of density, fails to increase the tensile strength as much as proper control of the dehydration prior to solidification.

There were 4 claims and the following references cited in this patent.

**United States Patents**

2,338,463, Skaupy, Jan. 4, 1944.

**Foreign Patent**

352,681, Great Britain, July 16, 1931.

## Miscellaneous Processes

*Electrophoretic coatings and compositions. Patent No. 2,894,888.* Filed September 7, 1956. Issued July 14, 1959. No sheets of drawings; none reproduced. Assigned to Vitro Corporation of America, by James J. Shyne and Wilson D. Fletcher and Mary Ester.

The invention comprises producing an inorganic coating of high wet strength on a conductive surface which comprises contacting said surface with a suspension of finely divided particles of said inorganic substance in a liquid vehicle selected from the group consisting of nitromethane, nitroethane and nitropropane and halogen derivatives thereof and electrophoretically depositing said particles from said suspension.

Electrophoretic coating may be carried out in any conventional electrolytic cell. The surface to be coated is cleaned by conventional cleaning steps, such as by degreasing, to remove foreign matter. In some cases we have found it advantageous to etch the surface to provide increased mechanical bonding of the electrophoretically applied coating to the base. To initiate deposition of the suspended particles a potential of between 50 and 500 volts d.c. per inch is applied between the electrodes. The current density used for the coating process depends upon the particular inorganic material, length of time to form the deposit, applied voltage and spacing of electrodes in the bath and the desired thickness of coating.

The following is an example of one particular type of treatment which we have found useful in permanently attaching a coating to a base.

32 grams of nickel oxide 81.3 grams of ferric oxide and 16 grams of chromium powder were ballmilled 8 hours in nitropropane. The resultant dispersion was then diluted with nitropropane to form an electrophoretic bath containing 10 per cent by weight of solids. A coating of 30 mil thickness was formed on a conductive surface of the base using a direct current potential gradient of 500 volts per inch in 15 seconds.

The deposited layer containing nickel oxide and ferric oxide and chromium was heated to a temperature between 200 and 500° C in a hydrogen atmosphere and stainless steel coating was produced. The coating was sintered at temperatures of from 600 to 1000° C. The sintered coating thus formed was porous and it was deemed necessary to eliminate this porosity in order that the stainless steel coating might be used for corrosion protection of the base metal.

After sintering, the coated article was cold-worked to achieve a desired densification. A high degree of densification, up to 100 per cent theoretical density, has been achieved by isostatically pressing the coated part at pressures up to 60,000 p.s.i. and then sintering to about 1000° C in an inert atmosphere.

There were 16 claims and the following references cited in this patent.

**United States Patent**

634,187, Great Britain, Mar. 15, 1950.

# Soon
# To Be Published
# Vol. II. HANDBOOK OF GLASS MANUFACTURE

Volume I of the Handbook of Glass Manufacture was originally published in 1953 by the Ogden Publishing Company. Uninterrupted demand for the book necessitated a second printing in 1957 in order to meet the needs of all those concerned with glass manufacture, technology and engineering. Both the first and second printing of Volume I have been sold out.

As a supplement to the first edition, Volume II of the Handbook of Glass Manufacture will be published on August 15, 1960, and will again be edited by Dr. Fay V. Tooley, Professor of Glass Technology, Department of Ceramic Engineering, University of Illinois.

CONTENTS . . .

**Chemical and Instrumental Analysis of Glass**
Francis Glaze, Consultant
John Time, Owens-Corning Fiberglas Corp.

**Optical Properties of Glass: Effects of Radiation on Glass**
Norbert J. Kreidl, Bausch and Lomb Optical Co.

**Scientific Glass Blowing**
Vincent DeMaria, Glass Products Development Laboratory

**Flat Glass Manufacturing Processes**
Roy G. Ehman, Pennsylvania State University

**The Quality Control Chart**
Ronald Wiley, Owens-Corning Fiberglas Corp.

**Electric Melting of Glass**
Larry Penberthy, Penberthy Electromelt Co.

**Constitution and Structure of Glass**
Fay V. Tooley, University of Illinois

The Glass Industry
55 West 42nd Street, New York 36, New York

Date.....

Enclosed please find remittance in the amount of $..... to cover the cost of ..... copy(ies) of Volume II of the HANDBOOK OF GLASS MANUFACTURE. Single copy price, $10.00. Order for 5 or more copies, 10% discount. Add Shipping and Insurance charges, domestic 60¢ per copy; foreign 90¢ per copy. Foreign remittance in U.S. dollars.

NAME.....

COMPANY.....

STREET..... CITY..... STATE.....

# CURRENT STATISTICAL POSITION OF GLASS

**Employment** in the glass industry during March, 1960, was as follows: *Flat Glass*: a preliminary figure of 31,100 for March, 1960 indicates a decrease of 0.2 per cent under the adjusted figure of 32,000 reported for February, 1960. *Glass and Glassware, Pressed and Blown*: An increase of 1.2 per cent is shown by the preliminary figure of 88,600 reported for March, 1960, when compared with the adjusted figure of 87,500 reported for February, 1960. *Glass Products Made of Purchased Glass*: the preliminary figure of 14,100 given for March, 1960 is 0.34 per cent under the adjusted figure of 14,500 reported for February, 1960.

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**Payrolls** in the glass industry during March, 1960, were as follows: *Flat Glass*: a decrease of 1.2 per cent is shown in the preliminary $16,905,177.84 given for March, 1960, when compared with February's $17,121,242.88. *Glass and Glassware, Pressed and Blown*: an increase of 2.6 per cent is shown in the preliminary $35,273,081.14 given for March, 1960, when compared with the previous month's adjusted $34,361,231.63. *Glass Products Made of Purchased Glass*: a preliminary figure of $4,353,040.13 was reported for March, 1960. This is a decrease of 2.0 per cent when compared with the adjusted figure of $4,499,777.17 for February, 1960.

---

**Glass Container Production** based on figures released by the Bureau of the Census, Industry Division, was 12,693,000 gross during April, 1960. This is a decrease of 7.4 per cent under the previous month's production figure, 13,708,000 gross. During April, 1959, glass container production was 13,340,000 gross, or 5.1 per cent over the April, 1960 figure. At the end of the first four months of 1960, glass container manufacturers have produced a preliminary total of 52,287,000 gross. This is 6.6 per cent more than the 49,044,000 gross produced during the same period in 1959.

---

**Glass Container Shipments** during April, 1960 came to 12,783,000 gross, a decrease of 2.3 per cent under March, 1960, which totaled 13,097,000 gross. Shipments during April, 1959 amounted to 12,715,000 gross, or 0.5 per cent less than April, 1960. At the end of the first four months of 1960, shipments have reached a preliminary total of 48,537,000 gross, which is 3.6 per cent more than the 46,818,000 gross shipped during the same period of the previous year.

Stocks on hand at the end of April, 1960 came to 20,986,000 gross. This is 0.1 per cent more than the 20,963,000 gross on hand at the end of March, 1960, and 11.2 per cent more than the 18,871,000 gross on hand at the end of April, 1959.

### GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

**Narrow Neck Containers**

| | April, 1960 |
|---|---|
| Food | 1,306,000 |
| Medicinal and Health Supplies | 1,268,000 |
| Chemical, Household and Industrial | 956,000 |
| Toiletries and Cosmetics | 848,000 |
| Beverage, Returnable | 1,114,000 |
| Beverage, Non-returnable | 171,000 |
| Beer, Returnable | 378,000 |
| Beer, Non-returnable | 1,065,000 |
| Liquor | 866,000 |
| Wine | 426,000 |
| Sub-total (Narrow) | 8,398,000 |

**Wide Mouth Containers**

| | |
|---|---|
| Food | *3,268,000 |
| Medicinal and Health Supplies | 380,000 |
| Chemical, Household and Industrial | 145,000 |
| Toiletries and Cosmetics | 275,000 |
| Dairy Products | 135,000 |
| Sub-total (Wide) | *4,203,000 |
| Total Domestic | 12,601,000 |
| Export Shipments | 182,000 |
| TOTAL SHIPMENTS | *12,783,000 |

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

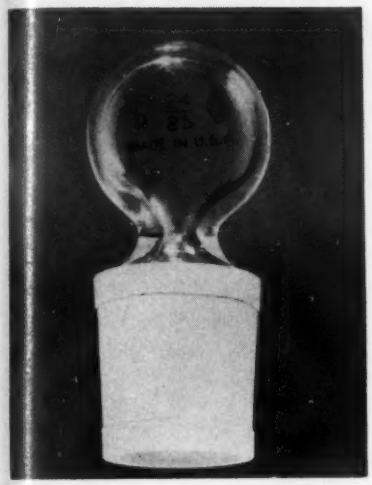
### GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

| | | Production April 1960 | Stocks April 1960 |
|---|---|---|---|
| Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics | Narrow Neck | 4,324,000 | 7,221,000 |
| | Wide Mouth | *4,361,000 | *6,866,000 |
| Beverage, Returnable | | 1,190,000 | 2,551,000 |
| Beverage, Non-returnable | | 171,000 | 277,000 |
| Beer, Returnable | | 342,000 | 514,000 |
| Beer, Non-returnable | | 958,000 | 990,000 |
| Liquor | | 825,000 | 1,457,000 |
| Wine | | 375,000 | 716,000 |
| Dairy Products | | 147,000 | 394,000 |
| TOTAL | | *12,693,000 | *20,986,000 |

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

# NEW EQUIPMENT AND SUPPLIES



### Tapered Stopper

Available with Teflon sleeve 1-1½ to 2 mm. thick in eight different sizes that fit either a medium or full length standard taper companion member. Sleeve is permanently attached to the borosilicate glass body by a special process and is claimed not to bind, stick or freeze.

Large sizes have a hollow glass body with conventional penny head or hexagonal head provided.

**Scientific Glass Apparatus Co., Inc., Bloomfield, N.J.**

### Sillimanite Cements

Improved formulations of high-quality sillimanite refractory cements are available in heat-setting and air-setting types, for bonding mullite, high alumina, kaolin, super-duty or fireclay brick and shapes in high temperature furnaces. Material is claimed to have improved workability in both dipping and trowelling consistency; excellent refractoriness with high bonding strength; superior resistance to slagging or erosion; and negligible shrinkage at high temperatures.

**Chas. Taylor Sons Co., 710 Burns St., Cincinnati 14, O.**

### Optical Abrasives

For the electronic field, crystal manufacturers, glass component fabricators, metal finishers, and lapping compound makers. Hexagonal-shaped particles of corundum are broken down to form the abrasives which range from 5 to 22 microns in size with a variance of not more than 1/5000 of an inch in any one of the six groups being manufactured.

**American Optical Co., Southbridge, Mass.**

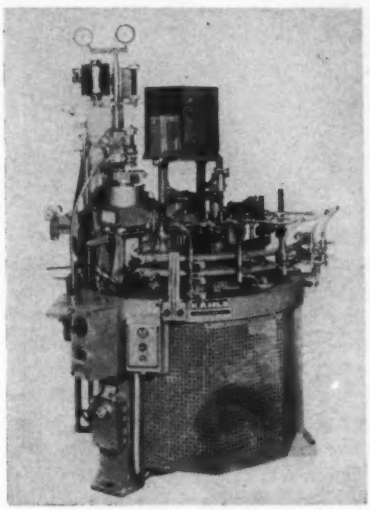
### Glass Edge Grinder

For production use in the automobile industry and for finishing edges of mirrors, table tops and other glass products. It finishes two bevels and a flat face on edges of glass panels with a single pass of the work.

Driven simultaneously by three 1-hp motors the three waterproof silicon carbide abrasive belts, measuring 3 or 4 in. x 84 in., can operate at 3800 surface feet per minute. Air cylinders control belt tension. Protective maintenance for extended belt life is accomplished by a water spray at the rate of 1 gallon per hour.

The glass sheets are slid past the grinding belts on free-turning plastic rollers or a felt covered table. A skilled operator is not required.

**Bush Mfg. Co., 900 Rochester Rd., Clawson, Mich.**



### Glass Diode Machine

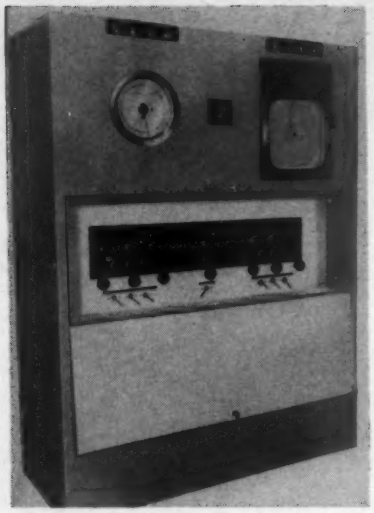
Automatic combination beading and cat-whisker welding machine for glass diodes that produces beaded leads with the formed cat-whisker welded to the lead. Lead wire is fed from the spool, straightened, cut-off, and beaded. Same operation is followed for the cat-whisker wire. Designed to permit 3-shift operations machine produces 1500 to 2000 units per hour.

**Kahle Engineering Co., 3322 Hudson Ave., Union City, N.J.**

### Lift Truck Attachment

Carton clamp attachment with a load side shift for use with electric trucks. The carton grab arm design is said to insure equal distribution of clamping pressures over the entire contact area so that the most fragile containers are handled without damage. High friction contact surfaces on the plates prevent scuffing and reduce the clamping pressure to a minimum. The attachment is claimed to be ideal for the palletless handling of electrical goods, packaged foods, appliances, and light and bulky materials.

**Lewis-Shepard Products, Inc., 125 Walnut St., Watertown 72, Mass.**



**Batch-Weighing System**

A bulk-materials batch-weighing system for use in multi-ingredient product formulation said to have a weighing accuracy of ± 0.25 per cent calibrated range; reproducibility of better than one part in 2000 and ability to batch-weigh two, three, four or more ingredients in programmed sequence, in any desired proportions. Operation is fully automatic after system parameters have been programmed. Feed and discharge devices, weigh hoppers and weight transmitters are individual equipment packages.

**Weighing & Control Components, Inc., Hatboro, Pa.**

**Glass Washer**

Cylinder brush glass washer and dryer that handles glass in any width from 36 to 96 inches. Washing and drying are completed in one operation using a heated detergent and air blowers. Any length of glass can be cleaned at speeds of 6 to 15 feet per minute or faster. All parts which come in contact with water are corrosion-proof. It is available with detergent tank and recirculating pump.

**Henry G. Lange Machine Works, Inc., 166 N. May St., Chicago 7.**

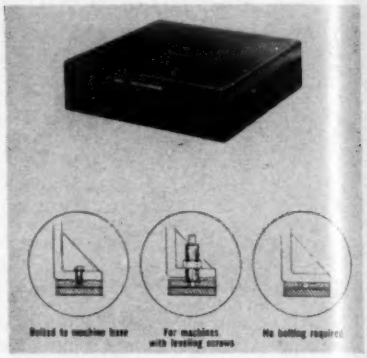
**Furnace Refractory**

New lightweight, castable insulation developed to fill a need for an extremely lightweight and good strength backup insulation in glass and ceramic industrial furnaces. Weight is 31 lbs. per cubic foot and cold crushing strength is 630 lbs. per sq. in. or approximately 45 tons per sq. ft. Reported to show no linear change or shrinkage from a cast to a dry state.

**J. H. France Refractories Co., 5110 France Rd., Show Shoe, Pa.**

**Fiber Glass Machine Mount**

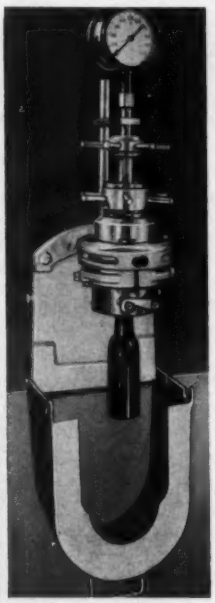
High density fiber glass to isolate vibration and eliminate the need to lag-down machinery. Produced in three standard sizes to handle load ranges up to 8,000 lbs. per mount. The product is claimed not to creep and to




permit mobile rather than permanently installed production machinery. Built-in level control is available on some models.

**Consolidated Kinetics Corp., 1065 Dublin Rd., Columbus 12, O.**


# HYDROSTATICALLY TEST BOTTLES IN SAFETY



TECO

## O. N. BREAK-TYPE BOTTLE TESTER

**Thoroughly tested in leading glass container plants. Proven to have definite and exclusive advantages.**

- **BREAKING PRESSURE** is recorded by a manual reset free pointer.
- **ACCURATE TESTS** are obtained. No increment factors involved as with testers using weights.
- **TESTING IS SAFE** as bottle breaks inside safety shield with parts dropping harmlessly into container below.
- **TESTING IS FAST** as there are no weights to handle and the required operations are simple and convenient.

The TECO TESTER will test all sizes from 7/16" I.D. finish up to and including jats with 62 mm finish. Gallon jugs with maximum radius of 2" from center of closure to outside of handle. Finish heights ⅛" to 2½" long can be tested. Write today for descriptive literature.

TOLEDO ENGINEERING Company INC.

*DESIGNERS AND BUILDERS OF GLASS MELTING FURNACES*

3003 Sylvania Ave. Toledo 13, Ohio

### Fiber Glass Air Filter

Equivalent to the electrostatic method of air cleaning and used where this method is not suitable or where a higher than normal degree of air cleaning is required.

Available in sizes to 72″ wide, in rolls 100 to 200 ft. long, or cut to specifications.

**Owens-Corning Fiberglas Corp., 717 Fifth Ave., New York, N. Y.**

### Cullet Conveyors

Cullet conveyors, trough belt style and inclined belt style, with sealed ball bearings and welded steel construction. Inclined belt conveyor is 12″ wide and has molded rubber cleats for easy handling and minimum roll back. Also available is a flat top chain single line conveyor built in sections for adaptation to diverse requirements. It features stainless or carbon steel flat top chain, variable speed drive, adjustable height supports, totally inclosed motor, adjustable drive for speed variation and sealed ball bearings. Normal speed range is 20 to 50 ft. per minute but other ranges are available.

**Stone Conveyor Co., Inc., Honeoye, N.Y.**

## CATALOGS RECEIVED

*Thermocouples.* Bulletin describing metal-sheathed ceramic insulated construction of thermocouples. Applications are cited and a table gives complete specifications of thermocouples available.

**THE BRISTOL CO., Waterbury 20, Conn.**

*Pyrex items.* (8 pages) Lists approximately 78 new items to the Pyrex brand laboratory glassware catalog. Includes product and price information on new reverse-taper stopcock plug and all-glass capillary column designed for high-temperature gas chromatography.

**CORNING GLASS WORKS, Corning, N. Y.**

*Mold cleaning.* (5 pages) Data sheet with specifications of caustic soda-gluconate solutions for electrolytic cleaning of cast iron glass forming molds. Includes cleaning cycle, storage and handling, packaging and operational recommendations and suggestions for the solution.

**CHAS. PFIZER & CO., INC., 630 Flushing Ave., Brooklyn 6, N.Y.**

*Furnace insulation.* Single sheet promotional bulletin on cast block mixes for backing up industrial furnace linings in the glass, chemical petroleum and other industries. Information is included on linear change, cold crushing strength and bulk density. Table and graph form illustrate thermal conductivity on "K" factors including mean temperatures from 250F to 1650F.

**J. H. FRANCE REFRACTORIES CO., 5180 France Rd., Snow Shoe, Pa.**

*Vibratory materials handling equipment.* (68 pages) Includes vibrators, car shakers, car rappers, packers and jolters, hopper level switches, flow control valves, feeders, conveyors, spiral elevators, dry feeders and weigh-feeding equipment, complete line of vibrating screens, test sieve, shakers, parts feeders, lapping machines, rectifiers and rectifier power units, battery chargers, shaft seals, paper joggers, paving breakers and rock drills, and rock drills, electric hammers and hammer drills and concrete vibrators and floats. Gives data and specifications on all products.

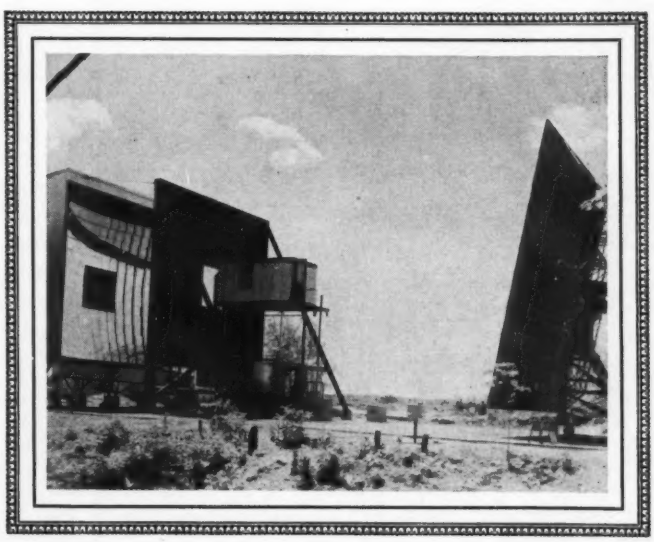
**SYNTRON CO., 156 Lexington Ave., Homer City, Pa.**


# How well do you know your glass?

**HERE YOU SEE A:**

- ☐ 1. Baseball backstop
- ☐ 2. Drive-in theater
- ☐ 3. Radar screen
- ☐ 4. Solar furnace

Light collected from 355 mirrors in heliostat (right) is focused in concave mirrors of concentrator (far left) to a single point with a temperature nearly 5000° F. This U.S. Army solar furnace is used to thermo test materials under study. In 70 years as a supplier of Soda Ash to the glass industry, Wyandotte has seen glass figure in many technological advances. Today, as in the past, Wyandotte is a working partner supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.



Wyandotte CHEMICALS

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*Wyandotte, Michigan • Offices in principal cities*

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**Translated from Russian into English**

This Soviet monthly, published for glass and ceramic researchers, technologists and production workers, provides Western scientists with reports on the latest technical advances from the laboratories and plants of the USSR.

Translation of GLASS AND CERAMICS, prompted by the recognition given to Soviet work in the field, permits you to take advantage of their intensified research program. Using these accurate translations by a staff of bilingual scientists can eliminate costly duplication of research. Scientists in this country can learn the specifics about how their Soviet counterparts upgrade products and improve processes; design unique, improved equipment; break production records and reduce costs.

GLASS AND CERAMICS will be published in the most effective manner possible to bridge the gap since this journal was last available in complete translation.

1956 and 1957 have been published. 1958 and 1959 will be brought out in four-issue volumes on a bimonthly basis until they are completed.

Subscription prices: $80.00 per year.
Foreign: $85.00 per year.

Also available in English:

1. 1st Conference on the Structure of Glass (held in Leningrad), 296 pp., profusely illustrated . . $20.00.
2. Proceedings of 2nd Conference on Structure of Glass, to be published soon . . $20.00.

Detailed tables of contents will be sent upon request.

Order on approval from:

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**227 W. 17th St., New York 11, N.Y.**

## CERIUM OXIDE IN GLASS POLISHING

(*Continued from page* 391)

chemical reactions which effect removal of glass and formation of a smooth surface.

That hydration of the glass surface is an important factor in polishing has been shown by experiments with pitch- and felt-polishing in the absence of any polishing oxide, whereby pronounced smoothing of the surface and some material loss resulted[3]. Chemical differences in a glass surface after polishing—depletion of sodium, increased acid solubility—also indicate changes occurring at the glass-water interface.

Thermoplastic deformation of a glass surface under the pressure of a sharp, hard object has been clearly demonstrated by electron microscope photographs, but only on a scale far larger than the molecular dimensions in which actual polishing occurs. A process of that nature could, of course, occur on a near-molecular scale, below the limits of electron microscope observation. In any event, the softened surface layer arising from hydration of the glass would be more susceptible to such "plastic displacement." Also, if temperatures approaching the softening point of glass actually are momentarily achieved in the area near a polishing oxide particle, the accelerative effect of such temperature on the rate of any chemical reactions involving the polishing oxide would certainly be as significant as the softening of the glass itself.

The polishing process has been summarized by Kaller[3] as a complex overlapping of the individual reactions of glass with water, polishing oxide with pad and glass, and pad with the hydrolyzed glass surface. Individually neither the water, the pad, nor the polishing oxide has more than a slight influence on the process, but their simultaneous effect is strong. The polishing oxide, by molecularly removing the unevenness of the glass, is considered the most significant component.

Though there seems to be increasing recognition of the chemical aspects of glass polishing, very little has been published concerning the specific chemical role of the polishing oxide. Increasing significance is coming to be attached to the basic crystal structure of a polishing oxide, rather than its external microscopic appearance, agglomerate size and shape, or hardness. Lattice disorders and the resultant high-energy sites within the crystal, both being directly related to the preparation conditions, have a profound influence on the polishing ability of an oxide. As stated by Kaller[3]:

> "The primary effect of the loose, intergrown agglomerates ranging in size from several hundredths to several microns results from the pulverization of these agglomerates down to the size of the primary crystallite of about 50-400 Angstroms. The true polishing process results from the very high mechanical energy required to further reduce the primary crystallites, with their many crystal defects, by rubbing of the polishing pitch or felt pad and the glass. . . . Since defect sites possess very great energy of formation, the freshly formed fracture surfaces of the primary crystallites, at the moment of their creation, show their greatest chemical activity. Only those defect sites which are within molecular distances of the glass surface at the instant of their first exposure react with

the components of the glass and carry it away with the motion of the polishing pad."

The optimum hardness of a polishing oxide crystal for any specific application can consequently be defined as that which results in exposure of the optimum quantity of nascent oxide crystal surfaces for reaction with the glass surface under the particular conditions of that polishing process. Too soft an oxide produces more active surfaces per unit time than can be utilized in polishing, the excess being consumed in adsorption of polishing products. Too hard an oxide will either produce fresh crystal surfaces too slowly for efficient polishing or will actually scratch the glass surface. It is thus seen that for each different combination of glass, polishing cloth or pitch, and pressure, an oxide of slightly different physical characteristics may give optimum results.

Differences in the size and shape of polishing oxide particles are shown in the electron micrographs in Figs. 9-12, made at 60,000X magnification. Proper interpretation of these shadow-type photographs is always difficult, particularly since the particles shown represent such an exceedingly minute fraction of the original oxide sample. Of interest, however, are indications of interfacial crystal angles (arrows, Oxides 1 and 2); fair confirmation of the 300-500 Angstrom crystallite size of cerium oxide, as determined by X-ray diffraction (below); and extremely small size and amorphous nature of zirconia obtained by precipitation methods (Oxide 3) as compared with that obtained by milling of a coarse zirconia grain (Oxide 4).

X-ray diffraction studies of high-cerium oxide have indicated some of the crystal properties of a good ceria-based polishing oxide. Well-formed crystallites of the face-centered cubic system, 300-500 Angstroms in diameter, with essentially symmetrical lattice dimensions, show superior polishing properties. Cubic cerium oxide with a more octahedral than cubic crystal habit or shape is less satisfactory for polishing. The sketches in Fig. 13 depict the apparent variations in crystal habits of such oxides, as postulated from X-ray data. Greater chemical reactivity, or higher ratio of cerium to oxygen atoms on one crystal face relative to the other, are interesting theories which have been proposed to explain this difference in polishing power. Analogous variations in the abrasive power on different faces of silicon carbide or alumina crystals, due to differences in reactivity at the metal-abrasive interfaces, have been reported[4]. The X-ray diffraction technique is also proving useful for studying the influence on polishing properties of crystal distortion or strain, resulting from special heat treatment or substitution of foreign ions into the ceria crystal. Increased chemical reactivity at defect sites in a cerium oxide crystal is a logical assumption in view of other more familiar examples of this behavior, such as initiation of


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rapid corrosion at points of strain or crystal defects in a metal surface.

The rate of progress in understanding the glass polishing phenomenon and the function of the polishing oxide in this process is increasing rapidly as the number of workers in the field grows and as the use of modern analytical instruments such as the electron microscope and the X-ray diffractometer is directed toward this problem. As the basic properties of polishing compounds become better known, the innovations in composition of such materials can be expected to multiply. Those industries engaged in polishing of glass will benefit from these innovations only to the extent that they are willing to explore the possible application of new polishing compounds to their own operation. With joint effort on the part of the manufacturer and the consumer, rapidly increasing use of this unique class of materials is inevitable.

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## 1960 OVERMYER IRON CLINIC

(*Continued from page* 395)

### Omnod (Ductile Iron)

This material represents a comparatively new family of cast metals which have considerably shortened a long-existent gap between cast iron and steel. Holding the process advantages of cast iron, it combines many of the engineering advantages of steel. Random graphite flakes which limit the strength and ductility of ordinary gray cast iron are changed in microstructure by the addition of an effective amount of magnesium in the melting process. The new spheroidal shape of the graphite removes the former weakening and embrittling effects. Machined surfaces resemble that of steel, and its ability to take a high polish is reflected in the improved lustre of the glass article.

### OM S-3

Successful as an I S 62 plunger material, this high chromium steel resists scaling of the chromium-oxide film which forms a protective coating against corrosion and rapid deterioration upon exposure to high temperatures. With less thermal expansion than the chromium-nickel grades, the straight chromium grades are best for applications where constant heating and cooling is involved. This is due to the fact that expansion and contraction of metal in applications requiring repeated heating and cooling accelerates the breaking or scaling of the oxide film.

### Electro-Cast

This is a process made possible through the duplexing of cupola metal by the induction furnace. Molten metal is brought from the cupola and transferred to an electric furnace where steel scrap is added. The metal reaches pouring temperature after a short melting period and the metal obtained is a high strength gray iron of predictable physical and chemical properties.

### OM-X Metal

In limited production at the present, the metal is a copper base alloy of high density and high thermal conductivity. Like the Electro-Cast process this non-ferrous base alloy is made possible by the induction furnace.

### Heat Treat and Annealng Process

To improve machinability and relieve internal stresses of gray iron casting it is annealed to a temperature sufficiently high to alter its structure. Maximum machinability is an important factor in all glass mold castings since modern production methods require high speed automatic machine tools with very high cutting speeds.

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### INDUSTRIAL FIBER GLASS FABRICS

(*Continued from page* 401)

Business Service Center, General Services Administration, Regional Office Building, 7th & D Streets, SW., Washington 25, D.C.

Progress in the development of improved yarns and fabrics has led to improved physical properties of the many materials which can be reinforced with fiber glass fabrics. These improvements have been, and will continue to be, reflected in new specifications for fiber glass as the needed data are collected and reviewed. I would hope that as many companies and people as possible would contribute their time, talent, and money to the preparation of meaningful standards and specifications working with such technical associations as ASTM and NEMA.

The Dept. of Defense has stated a policy recently of attempting to use as many industry standards as possible as the basis for military specifications. Great progress can be made in the area of specifications if each of the companies, who now have their own, would review theirs and compare them to presently available industry or military standards. The man-hours saved by the reference to an ASTM specification on a purchase order rather than to an involved individual company specification could be used to collect the information needed by the associations for the preparation of new specifications.

I am certain that any effort expended collectively in these technical areas will be far more valuable than if each one of us were to go his own way in setting up standards. The framework has been set up. It is up to all of us in the fiber glass reinforced plastics industry to use it.

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